CLAIMS

1. A method of thermographically separating lumpy feedstock, the method comprising feeding the feedstock lump by lump, exposing the feedstock to microwave radiation, recording induced radiation, detecting a valuable constituent, comparing the weight fraction of the valuable constituent in a lump with the threshold value of the fraction, and separating the lumps into useful aggregates and worthless material from the comparison, **characterised** in that each lump of the feedstock is exposed to microwave radiation, wherein upon interruption of the exposure with the heat exchanging processes between constituents of a target lump being damped, the heating pattern of the target lump is recorded wherefrom the mean temperature of the target lump is first measured and then the weight fraction of the valuable constituent in the target lump is found by the formula:

$$Q = \frac{(T_U - T_O)c}{U_O c_r - T_U(c_r - c) - T_O c},$$

wherein

Q is a weight fraction of a valuable constituent in a lump;

T_U is the steady-state temperature of a target lump;

T_O is the temperature of worthless material, to which it was heated;

U_O is the temperature of a valuable constituent, to which it was heated;

c_r is the heat capacity of a valuable constituent;

c is the heat capacity of worthless material;

then the condition

$$Q \geq Q_{nop},$$

wherein Q_{nop} is a threshold value of the weight fraction of a valuable constituent in a lump, is verified,

whereafter, from the finding of the weight fraction of the valuable constituent, the lumps of the feedstock are separated into two streams: one stream consisting of the lumps where the valuable constituent is present in an amount that is less than a predetermined threshold value, while the other stream consisting of the lumps where the valuable constituent is present in an amount that is not less than the same threshold value.

2. A method of thermographically separating lumpy feedstock, the method comprising feeding the feedstock lump by lump, exposing the feedstock to microwave radiation, recording induced radiation, detecting a valuable constituent, comparing the weight fraction of the valuable constituent in a lump with the threshold value of the fraction, and separating the lumps into useful aggregates and worthless material from the comparison, **characterised** in that each lump of the feedstock is exposed to microwave radiation, wherein upon interruption of the exposure and prior to damping of the heat exchanging processes between constituents of a lump, the heating pattern of the lump is recorded wherefrom the mean temperature of the lump is measured and then the volume concentration factor of the valuable constituent in the lump is found by the formula:

$$v = \frac{2T_C - \dfrac{U_O \cdot T_O}{T_C} - 2T_O + U_O}{3(U_O - T_O)},$$

wherein

v is a volume concentration factor of the valuable constituent;

Tc is the recorded mean temperature of a target lump;

U_O is the temperature of a valuable constituent, to which it was heated;

T_O is the temperature of worthless material, to which it was heated;

then the condition

$$\nu > \nu_{nop},$$

wherein

$\nu_{\partial on}$ is the threshold value of the volume concentration factor of the valuable constituent, is verified,

whereafter, from the finding of the volume concentration factor of the valuable constituent, the lumps of the feedstock are separated into two streams: one stream consisting of the lumps where the valuable constituent is present in an amount that is less than its predetermined threshold value, while the other stream consisting of the lumps where the valuable constituent is present in an amount that is not less than the same predetermined threshold value.

3. A method of thermographically separating lumpy feedstock, the method comprising feeding the feedstock lump by lump, exposing the feedstock to microwave radiation, recording induced radiation, detecting a valuable constituent, comparing the weight fraction of the valuable constituent in a lump with the threshold value of the fraction, and separating the lumps into useful aggregates and worthless material from the comparison, **characterised** in that a lump of the feedstock is exposed to microwave radiation during the time found by the expression:

$$t_{н} = \frac{\Delta T c_r \rho_r}{f \pi \varepsilon_0 \varepsilon_r E_m^2 tg\delta_r},$$

wherein

t_H is the time of exposure of the target lump to microwave radiation;

ΔT is the required temperature rise in heating the valuable constituent;

c_r is the heat capacity of the valuable constituent;

ρ_r is the density of the valuable constituent;

f is the microwave frequency;

ε_0 is the electric constant;

ε_r is the relative permittivity of the valuable constituent;

E_m is an electric intensity of microwave radiation;

$tg\delta_r$ is the tangent of the valuable constituent dielectric loss,

wherein upon interruption of the exposure and prior to damping of the heat exchanging processes between constituents of a lump, the heating pattern of the lump is recorded wherefrom the mean temperature of the lump is measured and then the weight fraction of the valuable constituent in the target lump is found by the formula:

$$Q = \frac{\rho_r Ae}{\rho_r Ae - \rho Ae_r},$$

wherein

$Ae = \pi f E_m^2 \varepsilon_0 \varepsilon tg\delta t_H - \Delta T_C \rho c$ is a fault-identifying variable of the worthless material;

$Ae_r = \pi f E_m^2 \varepsilon_0 \varepsilon_r tg\delta_r t_H - \Delta T_C \rho_r c_r$ is a fault-identifying variable of the valuable constituent;

Q is the mass fraction of the valuable constituent in the target lump;

ΔTc is the mean overheating of the target lump (*K*);

ρ is the density of the worthless material;

ε is the relative permittivity of the worthless material;

$tg\delta$ is the tangent of the worthless material dielectric loss,

then the condition

$$Q > Q_{nop},$$

wherein

Q_{nop} is the threshold value of the weight fraction of a valuable constituent in a lump, is verified,

whereafter, from the finding of the weight fraction of the valuable constituent, the lumps of the feedstock are separated into two streams: one stream consisting of the lumps where the valuable constituent is present in an amount that is less than its threshold value, while the other stream consisting of the lumps where the valuable constituent is present in an amount that is not less than its threshold value.

4. A method of thermographically separating lumpy feedstock, the method comprising feeding the feedstock lump by lump, exposing the feedstock to microwave radiation, recording induced radiation, detecting a valuable constituent, comparing the weight fraction of the valuable constituent in a lump with the threshold value of the fraction, and separating the lumps into useful aggregates and worthless material from the comparison, **characterised** in that each lump of the feedstock is exposed to microwave radiation, the frequency of which is found by the formula:

$$f \leq \frac{1}{\pi \cdot X_m \cdot \sqrt{2\varepsilon_0 \varepsilon_r \mu_0 \mu_r (\sqrt{1 + tg^2 \delta_r} + 1)}},$$

wherein

X_m is the maximum linear dimension of a lump;

ε_0 is the electric constant;

ε_r is the relative permittivity of the valuable constituent;

μ_0 is the magnetic constant;

μ_r is the relative permeability of the valuable constituent;

$tg\delta_r$ is the tangent of the valuable constituent dielectric loss,

and the heating time is calculated by the formula:

$$t_t = \frac{\Delta T c_r \rho_r}{f \pi \varepsilon_0 \varepsilon_r E_m^2 tg \delta_r},$$

wherein

ΔT is the required temperature rise in heating the valuable constituent;

c_r is the specific heat capacity of the valuable constituent;

ρ_r is the density of the valuable constituent;

ε_r is the relative permittivity of the valuable constituent;

E_m is the intensity of the electromagnetic field,

wherein upon interruption of the exposure and prior to damping of the heat exchanging processes between constituents of a lump, the heating patterns of the lump are repeatedly recorded, wherefrom the mean temperatures of the target lump are measured and from the measurements, a set of equations is formed:

$$\begin{cases} T_0 = X_1 + X_2 t_0 + X_3 t_0^2 + X_4 t_0^3 \\ T_1 = X_1 + X_2 t_1 + X_3 t_1^2 + X_4 t_1^3 \\ T_2 = X_1 + X_2 t_2 + X_3 t_2^2 + X_4 t_2^3 \\ T_3 = X_1 + X_2 t_3 + X_3 t_3^2 + X_4 t_3^3 \end{cases},$$

wherein

T_0, T_1, T_2, T_3 denote the mean temperature of a lump, taken at times t_0, t_1, t_2, t_3,

the set of equations is solved for X_1, X_2, X_3, X_4, whereupon the volume ratio of the valuable constituent is determined by the formula:

$$Kv = \frac{c\rho(X_3 a c_r \rho_r + 3X_2 k_r)}{c\rho(X_3 a c_r \rho_r + 3X_2 k_r) - 3X_2 c_r \rho_r k},$$

wherein

c is the heat capacity of the worthless material;

ρ is the density of the worthless material;

a is the particle size of the valuable constituent;

k_r is the heat transfer coefficient of the valuable constituent;

k is the heat transfer coefficient of the worthless material;

then the condition

$$Kv > Kv_{nop},$$

wherein

Kv_{nop} is the threshold value of the volume ratio of the valuable constituent, is verified,

whereafter, from the finding of the volume ratio of the valuable constituent, the lumps of the feedstock are separated into two streams: one stream consisting of the lumps where the valuable constituent is present in an amount that is less than a predetermined threshold value, while the other stream consisting of the lumps where the valuable constituent is present in an amount that is not less than the same predetermined threshold value.

5. A method of thermographically separating lumpy feedstock, the method comprising feeding the feedstock lump by lump, exposing the feedstock to microwave radiation, recording induced radiation, detecting a valuable constituent, comparing the weight fraction of the valuable constituent in a lump with the threshold value of the fraction, and separating the lumps into useful aggregates and worthless material from the comparison, **characterised** in that each lump of the feedstock is exposed to microwave radiation until the constituents of the lump are heated, wherein upon interruption of the exposure, the heating pattern of the target lump is recorded by means of a thermographic system upon interruption of the exposure to an electromagnetic field and prior to the damping of heat exchanging processes between constituents of a lump, wherein the difference between the maximum and the minimum temperatures of the lump is determined from the recorded heating pattern, and from the difference between the maximum and the

minimum temperatures and the known time from the interruption of the exposure to the recording of the heating pattern of the lump the weight fraction of the valuable constituent in the lump is found by the formula:

$$Q = \frac{cc_r \ln\left(\frac{U_O - T_O}{\Delta T(t_K)}\right) - \frac{6k_r c t_K}{a\rho_r}}{cc_r \ln\left(\frac{U_O - T_O}{\Delta T(t_K)}\right) + \frac{6(kc_r - k_r c)t_K}{a\rho_r}},$$

wherein

Q is the weight fraction of the valuable constituent in the target lump;

U_O is the temperature, to which the valuable constituent was heated;

T_O is the temperature of the worthless material, to which it was heated;

ρ_r is the density of the valuable constituent;

c_r is the heat capacity of the valuable constituent;

c is the heat capacity of the worthless material;

k_r is the heat transfer coefficient of the valuable constituent;

k is the heat transfer coefficient of the worthless material;

t_K is the time from the interruption of the exposure to the recording of the heating pattern of the lump;

a is the particle size of the valuable constituent in the target lump;

$\Delta T(t_K)$ is the difference between the maximum and the minimum temperatures of the lump as determined at the time of recording the heating pattern of the same lump;

then the condition

$$Q \geq Q_{nop},$$

wherein

Q_{nop} is the threshold value of the weight fraction of the valuable constituent, is verified,

whereafter, from the finding of the weight fraction of the valuable constituent, the lumps of the feedstock are separated into two streams: one stream consisting of the lumps where the valuable constituent is present in an amount that is less than a predetermined threshold value, while the other stream consisting of the lumps where the valuable constituent is present in an amount that is not less than the same threshold value.

6. An apparatus for thermographically separating lumpy feedstock comprising an arrangement for feeding feedstock lumps, including a receiving bin, an electrically driven feeder, an electrically driven conveyer; a microwave generator with a control system, induced radiation sensors, and a computing device with an input interface, **characterised** in that it further comprises a microwave heating chamber connected to the microwave generator, a thermographic system for processing signals from temperature-sensitive elements capable of detecting induced heat radiation, a control system for the feeder electric drive, a rolling handler, a control system for the conveyer electric drive, a narrow-beam light emitter and a photodetector, a position sensor, the output of the thermographic system is connected to the first input of the input interface, the output of the input interface is connected via the computing device to the input of the output interface, the second output of the output interface is connected to the control system for the feeder electric drive, the third output of the output interface is connected via the microwave generator control system to the input thereof, the fourth output of the output interface is connected to the control system of the conveyer electric drive, on the shaft thereof the position sensor is installed and connected to the second input of the input interface, wherein the first output of the output interface via a comparator, a time delay unit and a control pulse shaper is connected to a solenoid-operated pneumatic valve arranged so as to interact with a separator for directing to the receptacle of the feedstock lumps, where the valuable constituent is present in an amount that is less than a predetermined threshold value, and to the receptacle

of the feedstock lumps, where the valuable constituent is present in an amount that is not less than the same threshold value.

7. An apparatus for thermographically separating lumpy feedstock comprising an arrangement for feeding feedstock lumps, including a receiving bin, an electrically driven screw feeder, an electrically driven conveyer; a microwave generator with a control system, induced radiation sensors, and a computing device with an input interface, **characterised** in that it further comprises a microwave heating chamber connected, via an element for transmitting electromagnetic energy in the microwave spectrum, to the microwave generator, and housing a rolling handler consisting of rollers made from heat resistant dielectric material and a decelerating comb with teeth spacing equal to ¼ the wavelength of microwave radiation arranged between the rolls and the discharge unit of the microwave heating chamber is provided with a microwave trap having quarter wave reflectors, the apparatus further comprises a thermographic system for processing signals, a control system for the screw feeder electric drive, a control system for the conveyer electric drive, a narrow-beam light emitter and a photodetector, a position sensor, the output of the thermagraphic system is connected to the first input of the input interface, the output of the input interface is connected via the computing device to the input of the output interface, the second output of the output interface is connected to the control system for the screw feeder electric drive, the third output of the output interface is connected via the microwave generator control system to the input thereof, the fourth output of the output interface is connected to the control system of the conveyer electric drive, on the shaft thereof the position sensor is installed and connected to the second input of the input interface, wherein the first output of the output interface via a comparator, a time delay unit and a control pulse shaper is connected to a solenoid-operated pneumatic valve arranged so as to interact with a separator for directing to the receptacle of the feedstock lumps, wherein the valuable constituent is present in an amount that is less than a

predetermined threshold value, and to the receptacle of the feedstock lumps, wherein the valuable constituent is present in an amount that is not less than the same threshold value.